

SECTION 6.01 CONCRETE FOR STRUCTURES

6.01.01--Description: This item shall include concrete for use in bridges and culverts, walls, catch basins, drop inlets and other miscellaneous construction as required. The concrete shall be composed of portland cement, fine and coarse aggregate, admixtures if ordered, and water, prepared and constructed in accordance with these specifications, at the locations and of the form dimensions and class shown on the plans, or as directed by the Engineer.

The concrete shall be of three classes, Class "A," "C" and "F". The class to be used shall be as shown on the plans or designated herein, or as directed.

The use of truck-mixed or transit-mixed concrete is permitted for all Class "A," "C" and "F" concrete.

6.01.02--Materials: The materials for this work shall conform to the requirements of Article M.03.01.

6.01.03--Construction Methods:

1(a) Equipment: All equipment and tools used in the handling of materials, trucks used for transporting the batched material, the batching equipment, and concrete mixers used for the mixing of concrete shall comply with the requirements of Article 4.01.03. When permitted by the Engineer, mixers of the batch type design with a minimum rated capacity of a two-bag batch, may be used.

(b) Truck Mixed and Transit Mixed Concrete:

Definitions: Truck mixed concrete shall be construed to mean concrete mixed completely in a truck mixer after its arrival at the point of placement. Transit mixed concrete shall be construed to mean concrete mixed completely in a truck mixer while en route to the point of placement.

General Requirements: The location and capacity of the batch plant and complement of truck mixers for truck or transit mixed concrete shall be adequate for continuous placement of concrete in the forms.

If in the opinion of the Engineer, undue delay in deliveries do occur, and concrete already in place takes initial set, all such material in place may be rejected.

The batch plant, truck mixers and related equipment will be inspected by the Engineer; and these, as well as all methods of operation related thereto, shall be approved before the concrete is batched.

The concrete shall be discharged within one and one-half hours from the time the dry aggregates are loaded into the truck mixer; otherwise the concrete shall be disposed of by the Contractor at his expense.

With each delivery of concrete, the Contractor shall furnish a ticket indicating the proportionment of the batch and stamped by an approved time clock indicating the time the batch is placed in the truck mixer. This ticket shall be presented to the Engineer or his authorized representative before discharge of the concrete will be permitted.

After each time the drum of any mobile mixer is washed, the Contractor shall, at his own expense, add 0.02 m³ mixture of sand and cement for each cubic meter of concrete being placed in the drum of the mixer. The same proportions as specified for the concrete shall be used, and the mixture shall be introduced immediately before or at the time of batching.

Truck Mixers: The capacity of truck mixers shall be in accordance with the manufacturer's ratings, except that the maximum permissible capacities, expressed as percentages of the total volume of the drum or container, shall not exceed 63.25 percent.

Each truck mixer shall have an attached metal standard rating plate on which are stated the capacities, in terms of volume, of mixed concrete, for the various uses applicable to the equipment. When the manufacturer's ratings of capacity

are less than the limit indicated above, the manufacturer's ratings shall govern. Further, truck mixers shall be equipped with a suitable means by which the number of revolutions of the drum or blades may be readily verified.

Truck mixers shall be of standard type, size and manufacture and shall be either of the horizontal axis revolving-drum type, the inclined axis revolving-drum type, or the open-top revolving blade or paddle type.

Truck mixers must be inspected and approved by the Engineer.

Loading, Water and Transportation: The mix shall be in the proportions required for the work and placed in the drum of the mixer. Water shall be added to the mix, and the mixing conditions shall be in accordance with one of the following methods:

Truck-Mixed Concrete: Water shall be introduced into the mixing drum only after arrival at a level area on the site where the concrete is to be placed and under the supervision of the Engineer. The water shall be measured accurately by volume or mass by an approved adjustable measuring device which shall measure the required quantity under all operating conditions within a tolerance of 1 L or 1 percent, whichever is greater. The device shall be such that the flow of water shall be stopped automatically when the required quantity has been delivered. The mixer shall be equipped with an approved device which shall record the number of revolutions of the drum or blades during mixing. The mixing procedures shall be carried out at the site as hereinafter specified.

Transit-Mixed Concrete: Water shall be introduced into the mixing drum while the mixer is at the batch plant. The water shall be measured and controlled as specified above. The mixing procedure shall be carried out during transportation as hereinafter specified. Each truck mixer shall be equipped with a readily visible device that will record accurately the number of revolutions of the drum or blades at mixing speed from the moment of batching. This equipment shall be set into operation only at the batch plant by the inspector and shall be so constructed as to show evidence of any tampering or misoperation.

Any one of the following shall be sufficient cause for the rejection of any load of truck-mixed or transit-mixed concrete: when the elapsed time exceeds that which is permitted, when the mixing revolutions exceed 100, when the recording device has been tampered with or misoperated after the batching, when, at the time of placing, the air content or slump are not within specified ranges, when there is evidence of segregation or when initial set has taken place.

Mixing Procedure and Delivery: When the truck mixer is loaded in excess of 50 percent of the gross volume of the drum or container, the mixing period shall consist of not less than 60 revolutions of the drum or blades at mixing speed, after the water is added; if loaded to not more than 50 percent, the mixing period shall consist of not less than 40 revolutions of the drum or blades at mixing speed.

For the revolving drum type mixers the mixing speed shall be not less than 4 revolutions per minute of the drum nor greater than a speed which will produce a peripheral velocity of the drum of 1.14 m/s. For the revolving blade type mixers the mixing speed shall be not less than 4, nor more than 16, revolutions per minute of the mixing blades.

Agitating speed for both the revolving drum and revolving blade type of mixers shall be not less than 2, nor more than 6, revolutions per minute of the drum or the blades.

In no case shall mixing exceed 100 revolutions at mixing speed. Mixing beyond 100 revolutions shall be done at agitating speed.

In discharging truck mixers, the direction of rotation of drum or blades shall be manipulated so as to avoid segregation.

Slump: When the slump does not meet the specification requirements, modification of the concrete mix may be permitted if, in the opinion of the Engineer, no harmful effect upon the structural qualities or appearance of the concrete will result. If permitted by the Engineer, modifications shall be limited to the addition of not more than 30 kg of portland cement per cubic meter of concrete to decrease the slump or to the addition of water to increase the slump. The amount of water or cement added shall be further limited to the minimum needed to meet slump requirements. The cost of additional material and the work connected with each modification shall be borne by the Contractor. The addition of cement or water, or both, for the purpose of re-tempering concrete will not be permitted.

(c) Vibrators: Not less than two vibrating units, including source of power, shall be available on the work and shall be of the mechanical immersion type, in good operating condition at each pouring of concrete in order to insure satisfactory and uninterrupted vibration during placing. They shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4,500 impulses per minute. Vibrators shall be used only when directed by the Engineer.

(d) Trucking Equipment: Trucks used for the transporting of the batched material from the batcher plant to the mixer shall conform to the requirements of Subarticle 4.01.03-E.

2--Falsework and Centering: All falsework and centering required shall be adequate for the type of construction involved. Details of this construction shall be proposed by the Contractor and unless otherwise authorized shall be submitted to the Engineer for his information before construction is started. Approval of the plans or methods proposed for such construction shall not serve to relieve the Contractor of any of his responsibility for the successful completion of the project.

Suitable provision shall be made to secure the permanent camber required in the superstructure, and means of adjustment shall be provided so as to correct any possible settlement or deflection during construction. The method of adjustment shall be such as to permit the gradual lowering of the falsework or centering when these are to be removed. Falsework and centering shall remain in place for a period as stated in Subarticle 6.01.03-20. No falsework or centering shall be removed without the permission of the Engineer.

3--Forms: Forms shall be built true to lines and grades designated, shall be strong, stable, firm, mortar-tight and adequately braced or tied, or both. They shall be designed and constructed to withstand all loads and pressures including those imposed by plastic concrete, taking full account of the stresses due to the rate of pour, effect of vibration and conditions brought about by construction methods. Where necessary, forms shall be constructed to compensate for variations in camber of supporting members and allow for deflections.

Internal voids may be formed by the use of heavy paper or fiber forms especially made for this purpose, or with an alternate acceptable to the Engineer. These forms must be of substantial construction and adequately waterproofed in order to maintain their shape during the entire construction cycle. The end caps shall also be of similar construction. These forms shall be held in place against uplift or lateral displacement during the pouring and vibrating of the concrete by substantial wire ties or other satisfactory means. Before incorporating the forms in the work, a sample 1 m in length with end caps shall be furnished the Engineer for approval. These forms shall not be incorporated in the work until the Engineer has approved the sample submitted.

If requested, form work plans shall be submitted to the Engineer by the Contractor before form work is started. The furnishing of such plans, however, shall not serve to relieve the Contractor of any of his responsibility for the successful completion of the work.

Forms shall be filleted at all sharp corners, unless otherwise ordered or permitted, and shall be given a slight bevel or draft in the case of projections to insure satisfactory removal.

Materials for forms and their supports, ties and bracing, shall be of the type, quality and strength to achieve the foregoing requirements without impairment to the structural qualities or appearance of the concrete structure. Form material in contact with concrete shall be of a quality to provide the hereinafter required concrete surface smoothness; and, unless otherwise authorized, the contact surface shall be oiled with a light, clear paraffin base oil which will not damage, discolor or adhere to the concrete; or, as an alternate, the form may be lined with an approved composition form lining.

Materials and workmanship for forms for concrete to remain exposed in the finished work shall be such as to provide a smooth concrete surface of good appearance and texture, free of voids, indentations, protrusions or bulges and within tolerances consistent with good trade practices. If panels are used, they shall be evenly placed in columns or rows if their positioning is to be visible after the concrete is finished. These same requirements shall apply to forms for concrete not to remain exposed in the finished work except that minor irregularities where form boards or panels join and variations in form pattern will be acceptable.

Metal ties and anchors to hold the forms in alignment and location shall be so constructed that the metal work can be removed to a depth of at least 50 mm from the concrete surface without damage to the concrete. All cavities resulting from the removal of metal ties shall be filled with cement mortar of the same proportions used in the body of the work and the surface finished smooth and even, and if exposed in the finished work, shall conform to the texture and color of adjacent surfaces. With permission of the Engineer, the Contractor need not remove from the underneath side of bridge decks portions of metal devices used to support reinforcing steel providing such devices are of material, or are adequately coated with material, that will not rust or corrode.

Date of Completion: The year in which each structure is completed shall be shown in at least two places on each concrete superstructure unless otherwise ordered by the Engineer. Usually the date shall be placed in diagonally opposite ends of the bridge parapets on the side next to the roadway as shown on the plans. The numerals will be furnished by the Contractor. They shall be carefully set by the Contractor; and their subsequent removal after the concrete is placed and the finishing shall be carefully done so that the impression of the numerals in the concrete is clear and sharp, with no broken edges or other imperfections.

Ornament or Reverse Moulds: Ornamental work, when so noted on the plans, shall be formed by the use of reverse moulds. These moulds shall be produced by a qualified manufacturer approved by the Engineer. They shall be carefully built by the most approved modern methods and in accordance with the general dimensions shown on the plans. Additional details necessary to construct the moulds shall be worked out by the manufacturer and shall be such as to produce ornaments having the appearance indicated on the plans. The manufacturer shall prepare all detailed drawings that he may require for his guidance, and all such drawings as well as all models or carvings that he may prepare shall be approved by the Engineer before the moulds are made.

Moulds shall be carefully handled, shipped and stored so as to prevent all damage to the ornaments. They shall be delivered at the site of the work completely assembled and of the required size and shape in order to facilitate their proper placing. The Contractor shall be responsible for their condition at all times, and he will be required to remove and replace any damaged or defective moulds at his own expense.

The moulds shall be fitted into the surrounding form work so that they will act as a substitute for the ordinary forms which would be required in the area.

The surfaces of the moulds shall be given a coating of grease or lubricant to prevent the adherence of concrete. Any material which will adhere to or discolor the concrete shall not be used.

Utility Installations: On any structure where it becomes necessary to install any public utility, i.e., telephone, electric light or power conduits; gas, water or sewer pipes; pneumatic, oil or any other lines, the utilities concerned will furnish, delivered at the site, all material necessary for such installation.

Unless specifically otherwise ordered, the Contractor shall erect or install such equipment or material as shown on the plans; or if not shown thereon, he shall comply with the Engineer's instructions.

Whether or not the presence of any public utilities is mentioned on the plans or in the special provisions, the Contractor shall, by any means at his disposal, apprise himself of the location of any and all of them. He shall use every effort to protect them from damage of any nature whatsoever which might result from carelessness or negligence in any of his operations. He shall be held solely and strictly responsible for any damage resulting from such negligence or carelessness.

In cases where any utilities are to be installed on, under or within the construction limits of any structure--and the Contractor does not participate actively in the work--he shall arrange his operations as to cause no inconveniences or interruption to the progress of such installation. The Contractor shall extend his fullest cooperation to the construction forces of any utility company which may be operating within the limits of the contract.

4--Handling Material: The requirements of Subarticle 4.01.03-B shall apply.

5--Composition: The requirements of Subarticle 4.01.03-A shall apply except for the proportionment of the concrete mix which shall be in accordance with Article M.03.01, and the air content for Class "C" or Class "F," as the case may

be, used for bridge decks, including curbs, sidewalks and railings attached thereon or attached thereto. This concrete shall contain not less than 5 percent nor more than 7 percent entrained air at the time the concrete is deposited in the forms. For pumped concrete, the percentage of entrained air shall be determined at the placement end of the pump line.

Unless otherwise directed by the Engineer, all concrete for bridge decks shall contain a retarder admixture which the contractor shall add to the concrete mix in predetermined amounts varying with the temperature and other working conditions.

On any one structure, the admixture for a specific purpose shall be the particular product of one manufacturer only. When admixtures for different purposes are used together, the Contractor shall submit proof of their compatibility prior to use.

6--Consistency: The consistency shall be determined by the AASHTO Method T 119. A uniform consistency shall be continuously maintained. When Class "A" and Class "C" concrete is not to be vibrated, the allowable range of slump shall ordinarily be not less than 50 mm nor more than 100 mm. When Class "A" and Class "C" concrete is to be consolidated by vibration, the slump shall be not more than 60 mm; and for Class "F" concrete, the slump shall be not more than 78 mm. Slumps outside these limits shall be used when, in the opinion of the Engineer, conditions are such that satisfactory workability cannot be obtained within such limits. Concrete mixes designed by the Contractor so as to be pumpable shall not be subject to the above conditions. The desired slump shall be indicated on the mix design submitted for approval. The slump shall be determined at the placement end of the pump line.

7--Mixing Concrete: Mixing shall be in an approved mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Each mixer shall have attached in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

The mixing time requirements shall be in accordance with the recommendations of the manufacturer of the mixer. If a mixing time of less than 60 seconds is recommended, the Contractor shall furnish test data acceptable to the Engineer, verifying that the reduced mixing time will produce uniform concrete conforming to the provisions of AASHTO M157.

The mixer shall be operated at a drum speed as shown on the manufacturer's name plate on the approved mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meters, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to 10 percent above the mixer's nominal capacity may be permitted provided concrete test data for strength and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

Failure of the water measuring device or of the timing device shall result in suspension of mixing until correction has been made, except that, with prior approval of the Engineer, operations may be allowed to continue for the balance of the day if secondary controls can be demonstrated.

Truck mixed or transit mixed concrete may be used with the written permission of the Engineer for limited amounts or other exceptional cases. If its use is so allowed, the provision of Section 6.01 relating to truck mixers and truck mixed and transit mixed concrete shall fully apply.

The first batch of concrete materials placed in the mixer shall contain an additional quantity of sand, cement, and water sufficient to coat the inside surface of the drum without diminishing the mortar content of the mix. Upon the cessation of mixing for any considerable length of time, the mixer shall be thoroughly cleaned.

Hand mixing shall not be permitted except in cases of emergency and with the permission of the Engineer. When permitted, it shall be done only on watertight platforms. The sand shall be spread evenly over the platform, and the cement spread upon it. The sand and cement shall then be thoroughly mixed while dry by means of shovels until the mixture is of a uniform color, after which it shall be formed into a "crater" and water added in an amount necessary to produce mortar of the proper consistency. The material upon the outer portion of the "crater" ring shall then be shoveled to the center and the entire mass turned and sliced until a uniform consistency is produced. The coarse aggregate shall then be thoroughly wetted and added to the mortar and the entire mass turned and returned at least six (6) times and until

all of the stone particles are thoroughly covered with mortar and the mixture is of a uniform color and appearance. Hand mixed batches shall not exceed 0.5 m³ in volume. Hand mixing will not be permitted for concrete to be placed under water.

8--Placing Concrete: Concrete, except for central plantmix, truck or transitmixed, shall be placed in the forms immediately after mixing; and in no case shall concrete be used which does not reach its final position in the forms within 60 minutes after the time that water is first added to the mix, except that the Engineer reserves the right to alter this time by as much as one-half when necessary to achieve the requirements related to set and plasticity.

The use of long chutes and troughs for conveying concrete from the mixing plant to the forms will be permitted only on authority from the Engineer. If such conveyors are allowed and the quality of concrete as it reaches the forms or the method of placing or working it therein are not satisfactory, the Engineer may order their use discontinued and the substitution of a satisfactory method of placing. Where steep slopes are required, chutes and troughs shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete. Open troughs and chutes shall be either of metal or metal lined and shall extend as nearly as possible to the point of deposit. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided.

During placing operations, the concrete shall not come in contact with any aluminum.

Unless permission is obtained from the Engineer, concrete shall not be dropped a distance of more than 1.5 m; and special care shall be taken to fill each part of the forms by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and the concrete forced around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred; and no strain shall be placed on the ends of projecting reinforcement.

Concrete shall be placed in horizontal layers. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set, to prevent injury to the green concrete and to avoid surfaces of separation between the layers.

Concrete shall be compacted by continuous working with suitable tools or by vibrating as ordered by Engineer. The number and type of vibrators required, the length of the vibrating period and the location of the vibrators shall be as required by the Engineer.

Special care shall be taken in placing and compacting concrete around ornamental moulds, and vibrating equipment shall be used with caution. The vibrator shall not touch the moulds at any time. A gentle vibration shall be used, sufficient to assure the proper flow of the materials and to bring the mortar into complete contact so that all contours of the ornaments will be sharp. Tarpaulins or heavy paper shall be hung over the moulds, the bottom of which shall be kept constantly immersed in the fresh concrete, in order to prevent splashing the surfaces of the moulds.

When the placing of concrete is temporarily discontinued, the necessary keys or joints shall be formed as shown on the plans or as ordered, and the concrete after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete.

Joints shall be formed only in the locations shown on the plans or as permitted by the Engineer. Feather edges at construction joints will not be permitted.

Immediately following the discontinuance of the placing of concrete, all accumulations of mortar splashed upon reinforcing steel and the surface of the forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If accumulations are not removed prior to the concrete becoming set, care shall be taken not to injure or break the concrete-steel bond, at and near the surface of the concrete, while cleaning the reinforcing steel.

9--Concrete for Bridge Decks: Unless otherwise indicated on the plans or in the Special Provisions, concrete for use in bridge decks, including curbs, safety curbs, sidewalks, parapets and concrete railings placed thereon or attached thereto, shall be Class "F" concrete.

At least 15 days before the erection of the screed rails, the Contractor shall submit his screed erection plans, grades and sequence of concrete pours and proposed rate of placing concrete for review by the Engineer. These plans shall include details of equipment to be used in the placement and finishing of the concrete, including the number and type of personnel who will be engaged in placing the deck concrete. The personnel shall consist exclusively of persons with skill and experience appropriate to their working assignments.

When setting screed rails for mechanical finishing, the Contractor shall take into consideration and make proper allowances for the deflection of the bridge superstructure due to all operations.

(a) Composition: The composition shall be as specified in Subarticle 6.01.03-5.

(b) Placing Concrete: Bridge decks shall be finished by an approved mechanical finisher insofar as practical, and screed rails shall not be placed within the roadway area unless specifically permitted by the plans or the Engineer.

The completed surface shall be constructed in accordance with grades and cross slopes shown on the plans. When tested with a 3 m straightedge, the surface shall not vary more than 3 mm in 3 m. Variances greater than this which, in the opinion of the Engineer, may adversely affect the riding qualities of the surface shall be corrected; and this shall be done at the expense of the Contractor.

The Contractor shall notify the Engineer at least 24 hours in advance of his intention to place concrete.

All concrete shall be placed during daylight, and the placing of concrete shall not be started unless the intended pour can be completed and finished during daylight hours; except that when an adequate and approved lighting system is provided beforehand, the Engineer may waive this requirement.

Concrete shall be deposited in such a manner that the total deflection or settlement of supporting members, and the final finishing of the surface, shall have occurred before the initial set of the concrete takes place.

When construction joints are shown on the plans, or approved by the Engineer, all concrete between consecutive joints shall be placed in a continuous operation.

In order to allow for shrinkage, concrete shall not be placed against the second side of the construction joints for at least 12 hours after that on the first side has been placed, unless otherwise authorized or ordered by the Engineer.

Workmen will not be permitted to walk in the fresh concrete after it has been screeded. All finishing work, including the application of the fog spray and placement of the curing mats, shall be performed from bridges supported above the deck surface. A minimum of two bridges shall be available for the various operations.

Concrete shall be placed in a uniform manner across the entire width being poured, and only two passes of the transverse screed will be allowed over a given deck area, except as otherwise permitted by the Engineer.

After the concrete has been consolidated and brought to the proper elevation by the screed machine, it shall be further smoothed by use of a longitudinal float of suitable and approved design. The float shall be worked from a bridge with a dragging motion while held in position parallel to the roadway centerline and passed gradually from one side of the deck to the other.

During finishing operations, water shall not be applied to the concrete surface for purposes of retempering.

(c) Finishing: The deck shall be given a final transverse-tined texture in cases where the membrane waterproofing is omitted.

The texturing shall be applied to the plastic surface of the concrete using a mechanical self-propelled device designed to ride the screed rails. The texturing operation shall be performed in two stages:

(1) Dragging with Burlap. The burlap shall be at least 1 m wide and of a length 1 m greater than the distance between rails. The burlap shall not have frayed edges and shall be kept wet and clean of accumulations of dried concrete particles

or other foreign materials, which might leave distinctive undesirable marks. The burlap shall be drawn longitudinally along the surface in a slow manner so as to leave an even texture. When not in use, the burlap shall not be allowed to rest on the pavement.

(2) Texturing with Metal Tines. As soon as possible, after the pavement surface has been dragged with burlap, mechanical equipment shall be used to texture the surface with deep transverse grooves. The equipment shall consist of a self-propelled mechanical rig capable of applying a textured finish transverse to the centerline of the bridge. The texturing shall be accomplished with metal tines 0.75 mm thick, 2.0 mm wide and 100.0 to 150.0 mm in length with an average spacing of 12.0 mm on centers.

The transverse grooving shall be performed when the condition of the concrete is optimum. This condition will prevail when the grooves can be formed to a maximum depth of 5.0 mm with relative ease and without the walls of the grooves closing in on each other.

The tined grooving shall extend across the pavement to within 300 mm of the edge of the pavement on each side. The tining mechanism shall be aligned so as to prevent overlapping of grooves in any two successive transverse passes. The depth of the grooves formed in the surface by the tines shall be checked randomly with a tire-tread depth-measuring gage furnished by the Contractor to ensure compliance with the required limits of 3.0 to 5.0 mm. The original surface of the concrete before tining shall serve as the datum for the depth measurements.

Prior to starting work, the Contractor shall submit for approval a plan to protect the concrete in case of adverse weather. All materials required by the approved plan must be on hand at the time of concrete placement.

After completion of the placing and finishing operation--and for at least 12 hours after the concrete has set--the Contractor shall not operate any equipment in the immediate vicinity of the freshly placed concrete if the tare mass of the equipment exceeds 1150 kg. The immediate vicinity is defined as any distance within which the operation of equipment would, in the opinion of the Engineer, cause excessive vibration, movement or deflection of the forms.

(d) Curing: All concrete shall be kept constantly moist and protected against any drying action and cured for no less than seven (7) days after the placing of the concrete, and shall be accomplished in the following manner:

(1) Fog Spray: Curing of the concrete shall begin by the application of a water fog spray immediately after the initial set. Fog spraying shall continue until such time as the moist cotton mats are placed. The amount of fog spray shall be strictly controlled so that accumulations of standing or flowing water on the surface of the concrete shall not occur. There shall be a sufficient amount of spray to keep up with the placing operations.

Should atmospheric conditions render the use of fog spray impractical, the Contractor shall use plastic covers of suitable thickness and securely fastened down, but not directly in contact with the deck concrete. The covers shall be used only until the initial set has taken place, whereupon moist cotton mats shall be placed immediately thereafter and kept wet for the duration of the curing period.

On the windward side of the panel being cured, the Contractor shall erect barriers of suitable height, when necessary, to protect the curing concrete from the direct force of the wind.

(2) Moist Curing: When the concrete has set sufficiently, moist curing conforming to Subarticle 4.01.03-F.7(b) shall be substituted for the fog spray. The concrete shall be immediately covered with the moist cotton mats upon discontinuance of the fog spray. The mats shall be kept saturated by means of soaker hoses, garden spray, or other approved methods and remain in place for the required curing period.

Particular attentions shall be given to horizontal construction joints in parapet, curb, sidewalks and median areas to assure that the moist mats are in contact with the concrete surface.

10--Depositing Underwater Concrete: Concrete shall not be exposed to the action of water before setting, or deposited in water, except with the approval of the Engineer and under his immediate supervision. When concrete is so deposited, the method and manner of placing shall be as hereinafter designated.

The Contractor shall design and submit to the Engineer a concrete mix that he proposes to use. The mix shall be designed in accordance with the applicable sections of ACI 211 and ACI 318.

During placing operations, the concrete shall not come in contact with any aluminum.

Concrete deposited under water shall be carefully placed in a compacted mass in its final position by means of a tremie, a bottom dump bucket or other approved method and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water, and all form work designed to retain concrete under water shall be watertight. The consistency of the concrete shall be carefully regulated, and special care shall be exercised to prevent segregation of the materials. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. Concrete deposited under water shall be placed continuously from start to finish whenever possible, and each succeeding layer shall be placed before the preceding layer has taken initial set.

When a tremie is used, it shall consist of a suitable hopper and a tube having a diameter of not less than 254 mm; if the tube is constructed in sections, it shall have watertight couplings. The means of supporting the tremie shall be such as to permit the free movement of the discharge end over the area of the work and shall be such as to permit it to be rapidly lowered when necessary to choke off or retard the flow. The discharge end shall be plugged at the start of the work to prevent water from entering the tube. It shall be entirely sealed at all times, and the tremie tube kept full of concrete to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow shall then be stopped by lowering the tremie. The flow shall be continuous until the work is complete.

When concrete is placed by means of a bottom dump bucket, the bucket shall have a capacity of not less than 0.8 m³. The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. It shall then be raised very slowly as the concrete is discharged, the intent being to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture.

Before placing substructure concrete, all laitance or other unsound material shall be removed from the surface of the underwater concrete.

11--Concrete Exposed to Sea Water: Concrete structures so located as to be subject to the action of sea water shall be constructed to provide a maximum resistance to its disintegrating action.

The concrete shall be mixed not less than 2 minutes. The water content shall be carefully controlled and so regulated as to produce concrete of maximum impermeability. In placing concrete, care shall be exercised to avoid the formation of stone pockets; and the concrete shall be thoroughly compacted to the satisfaction of the Engineer. The original surface of the concrete shall be left undisturbed. In order to secure a thick and dense surface film, the surfaces of the forms shall be heavily coated with shellac or an approved form oil.

The range of possible disintegration of the concrete from an elevation below that of extreme low tide to an elevation above that of extreme high tide shall be determined by the Engineer; and except with his special permission, no construction joints shall be located within this range. In the determination of this range, due consideration shall be given to wave action, ice formation and other conditions affecting the extreme limits of possible deterioration and disintegration.

12--Concreting in Cold Weather: During the period from October 15 to April 15 of the subsequent year, cold-weather concreting procedures shall be employed by the Contractor, unless otherwise directed by the Engineer. Cold-weather concreting practices shall include taking measures to ensure that the temperature surrounding the structure is kept above 16° C for a period of five days after placing the concrete, and above 5° C for an additional nine days. The temperature shall then be gradually lowered to that of the surrounding atmosphere. Concrete test specimens prepared during the period noted shall be cured in the same manner as the structure that they represent, in accordance with ASTM C 31 (AASHTO T 23). If tests performed on the specimens indicate that sufficient strength has been achieved, the Engineer may reduce the amount of time that the structure must be protected and heated.

Sufficient heating apparatus of the kind approved by the Engineer, such as stoves, salamanders, or preferably steam equipment, and fuel to furnish all required heat, shall be supplied. All water used for mixing concrete shall be heated but shall not exceed a temperature of 65° C.

The temperature of the mixed concrete shall not be less than 16° C at the time of placing in the forms.

If aggregates are heated either by steam or by dry heat, the temperature of the aggregate shall be not less than 10° C, nor more than 37° C. The heating apparatus shall be such as to heat the mass uniformly and preclude the possibility of the occurrence of hot spots which will burn the material. There will be no additional compensation for the use of such heating equipment, but the cost thereof must be included in the cost of the concrete.

In case of extreme weather conditions, the Engineer may at his discretion vary the temperature limitations for water, aggregate and mixed concrete.

Except for deck slabs and thin wall sections, form insulation may be substituted for a heated enclosure, provided it can be demonstrated to the satisfaction of the Engineer that the insulation material proposed for use will keep the concrete within the above specified temperature limits for the specified periods of time. When the use of form insulation is permitted, sufficient provision shall be made by the Contractor so that the surface and interior temperature of the concrete may be determined. If the thermometric readings indicate that the required temperature is not being maintained, the structure shall be promptly enclosed and heat furnished as provided hereinabove.

When form insulation is substituted for a heated enclosure, forms shall not be stripped until permission is granted by the Engineer.

13--Anchorages: Anchor bolts and similar materials which are to be placed either at the time the substructure is built, or during the erection of the superstructure, shall be carefully and accurately set to the requirements of the plans or as ordered at such time as the Engineer may approve or direct.

(a) Setting Anchorages at time of Placing Substructure Concrete: When noted on the plans or ordered by the Engineer, the anchor bolts and similar materials shall be accurately set prior to placing concrete for the bridge seat.

(b) Setting Anchorages in Formed Holes: When indicated on the plans, the anchor bolts and similar materials shall be accurately set in formed holes in accordance with details and dimensions shown.

The space around the anchorage material shall be completely filled with non-shrink, non-staining grout conforming to the requirements of Subarticle M.03.01-12.

(c) Setting Anchorages in Drilled Holes: When the Contractor is not required to set anchorages at the time of constructing the substructure, he may set the anchorages as in (a) and (b) above, or he may drill holes having a diameter of 100 mm and a depth suitable to receive the bolts in the correct locations perpendicular to the plane of the bridge seat. Anchor bolts shall be grouted into clean drilled holes in accordance with the requirements of "Setting Anchorages in Formed Holes." When anchorage material is to be furnished by the Contractor for the superstructure and placed by the Contractor of the substructure, the necessary material shall be fabricated and delivered to the site of the work at such times as it may be required for proper inclusion in the substructure construction.

In locating anchor bolts in relation to slotted holes in expansion shoes, due consideration shall be given to the temperature at the time of erection.

Anchor bolt holes shall be clean and free of dirt, moisture or other foreign materials at the time of setting anchor bolts. Precaution shall be taken to prevent damage to concrete due to freezing of water in anchor bolt holes.

14--Preparation of Bearing Areas: The areas of masonry upon which the bases, pedestals or shoes are to rest shall be carefully finished by grinding if necessary to a smooth, even surface of the required elevation, and shall show no variations from a true plane greater than 1.5 mm over the entire area upon which the shoes are to rest.

15--Placing Superstructure: No superstructure load shall be placed upon any finished pier or abutment without the approval of the Engineer.

16--Placing Pipes and Conduits: Pipes and conduits which are to be carried by the structure as shown on plans or as ordered shall be placed by the Contractor during construction. Such pipe and conduits will be delivered to the Contractor, unless otherwise noted on plans or in the Special Provision, at the site of the work, by the Department or by others for whose use they are intended.

17--Construction Joints: Construction joints other than those shown on the plans will not be permitted without prior approval of the Engineer. When the placing of concrete is to be interrupted and a construction joint formed, provision shall be made for interlocking with the succeeding layer by roughening the surface and providing keyways, dowels or similar construction shown on the plans or as ordered.

In joining fresh concrete to concrete that has already set, the work already in place shall have its surface cut over thoroughly with a suitable tool to remove all loose and foreign material. This surface shall then be washed and scrubbed with wire brooms and thoroughly drenched with water until saturated. It shall remain saturated until the new concrete is placed. Immediately prior to the placing of the new concrete, all forms shall be drawn tight against the concrete already in place.

In construction joints exposed to view or in other construction joints where seepage of water is particularly objectionable, a baffle strip of copper, zinc, sheet lead or other approved materials shall be inserted. This strip shall be placed not less than 80 mm from the face of the concrete and shall extend into each section of the concrete a distance of not less than 50 mm.

18--Expansion Joints: Expansion joints shall be built in the locations and to the dimensions and details shown on the plans.

Sliding surfaces of metal shall be planed true and smooth, the marks of the plane paralleling the movement of the joint. Expansion plates shall be well anchored as shown on the plans. All sliding surfaces of expansion plates shall be thoroughly coated with graphite or other approved lubricant just before being placed in position and special care taken to avoid placing concrete in such manner as to interfere with their free action.

Open joints shall be placed at locations designated on the plans and shall be formed by the insertion and subsequent removal of templates of wood, metal or other suitable material. The templates shall be so constructed that their removal may be readily accomplished without injury to the work.

Filled joints shall be made with a joint filler, the materials for which shall conform to the requirements of the plans and of these specifications.

Mortise joints shall be as shown on the plans and, in general, shall consist of a tenon of concrete or metal sliding in a suitable concrete or metal socket or mortise. The construction shall be such as to permit freedom of movement and such as to be, as far as possible, watertight and rust proof. Metal flashing shall be used as shown on the plans or when ordered by the Engineer.

Special types of expansion joints shall conform to the dimensions and details shown on the plans.

19--Curing Concrete: Concrete surfaces exposed to conditions causing premature drying shall be protected by covering, within 2 hours of placing. Concrete shall be cured as specified in Subarticle 4.01.03-F.7 except Liquid Membrane-Forming Curing shall not be used. Other means of curing may be used provided that by either field or laboratory demonstration it can be shown that the material, or method used, sufficiently supplies necessary moisture to the concrete or causes the concrete to retain moisture, is not injurious to concrete and is not toxic.

Curing shall continue for a period of not less than 7 days after placing the concrete. Other precautions to insure the development of strength or to prevent injury shall be taken as the Engineer may direct.

20--Removal of Forms: The forms for any portion of the structure shall not be removed until the concrete is strong enough to avoid possible injury from such removal. Forms and their supports shall not be removed without the approval of the Engineer. Supports shall be removed in such a manner as to permit the concrete to take up the stresses due to its own mass uniformly and gradually.

If field operations are controlled by flexural-strength tests, the flexural strength of the concrete in the structure shall be monitored by the penetration-resistance tests, except in cases where the Engineer directs the use of third-point loading of test beams or splitting-tensile tests of cylinders. In this case, the Engineer shall be guided by the following considerations: penetration-resistance tests will be valid only for concretes containing coarse traprock aggregate with a topsize to 38 mm; beam tests will be valid for concrete containing all types and sizes of coarse aggregates; and, splitting-tensile tests will be valid for concrete containing any size of traprock aggregate.

If field operations are controlled by cylinder tests, the removal of forms, supports and housing and the discontinuance of heating and curing may be begun when the strengths reach the values which shall be fixed by the Engineer.

If field operations are not controlled by one of the above tests, the following period, exclusive of days when the temperature is below 5° C, may be used as a guide for the removal of forms:

Arch Centers	14 to 28 days
Centering Under Beams	14 to 28 days
Floor Slabs	7 to 14 days
Walls	24 hours to 4 days
Columns	2 to 7 days

To facilitate finishing, side forms carrying no load may be removed after 24 hours with the permission of the Engineer, but the curing process must be continued for seven days.

Ornament moulds shall be removed in the same manner as the usual form work. In case a portion of the plaster work remains in the concrete after the mold is removed, this material shall be carefully removed with a wood chisel, wood mallet or wire brush, using a chipping action wherever possible, and taking care that no damage is done to the concrete. No work of this nature shall be started until at least ten days after the forms have been removed.

21--Surface Finish: The external surface of all concrete shall be thoroughly worked during the operation of placing by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and thoroughly work the mortar against the forms to produce a smooth finish free from water and air pockets, segregated materials, or honeycomb. Unless otherwise authorized by the Engineer, the surface of the hardened concrete shall be finished immediately after the removal of the forms. All voids and honeycomb on the surface shall be filled and finished to conform to the surrounding concrete surface immediately after the forms are removed and before the finishing process is started. The finish shall be governed by the "Table of Finishes" shown elsewhere herein.

Float Finish: This finish shall be formed by placing an excess of material in the form and removing or striking off of such excess with a template, forcing the coarse aggregate below the mortar surface. There shall be created no concave surfaces in which water will be retained. After the concrete has been struck off as above described, the surface shall be thoroughly worked and floated with a wooden, canvas or cork float, the operation to be performed by skilled and experienced concrete finishers. Before this last finish has set, the surface shall be lightly stripped with a fine brush to remove the surface cement film, leaving a fine grained, smooth, but sanded texture. Curing, as specified elsewhere, shall follow.

Grout Clean-Down Finish: As soon as all cavities have been filled as required elsewhere and the cement mortar has set sufficiently, grout clean-down shall be performed as follows:

(1) All burrs, unevenness, laitance, including that in air holes, and any other material which will adversely affect the bond of the grout to the concrete, shall be removed by approved methods. This cleaning shall be done from the top or uppermost part of the surface to be finished to the bottom.

(2) A mixture of a fine aggregate and portland cement shall be thoroughly blended while dry. The proportions shall be such that when mixed with the proper amount of water, the color will match that of the concrete to be finished. The proportions shall be determined by trial panels. Water shall be added to this mixture in an amount which will bring the grout to a workable thick paint-like consistency.

(3) The surface to be treated shall be thoroughly wetted with a sufficient amount of water to prevent the absorption of water from the grout. Grout shall then be applied to the wetted surface before setting of the grout occurs. Grout which has set shall not be retempered and shall be disposed of by the Contractor at his expense.

The grout shall be uniformly applied by brushes, spray gun, or sponge rubber float over the entire surface, completely filling all air bubbles and holes. Immediately after applying the grout, the surface shall be floated with a cork, or other suitable float, scouring the surface vigorously. While the grout is still plastic, the surface shall be finished with a sponge rubber float, removing all excess grout but without removing grout from holes or depressions.

(4) The surface shall be allowed to dry thoroughly, and shall then be rubbed vigorously with burlap to remove completely any dried grout. No visible film of grout shall remain after this rubbing. Operations (3) and (4) shall be completed in one and the same day for the area treated.

(5) Curing of the concrete so treated shall then be resumed as specified elsewhere or, if completed, for at least one more day.

TABLE OF FINISHES

STRUCTURE	TYPE OF FINISH		FLOAT	GROUT CLEAN DOWN	RUBBED
	PART	AREA			
BRIDGE	Abutment	Exposed		X	
	Wings	Top	X		
		Exp. Sides			X
	Piers	Top	X		
		Exp. Sides			X
	Parapets	Top	X		
		Sides			
		& Fascia	X		
	Seat		X		
	Bearing Areas *		X		
	Sidewalks	Top	X		
	Curbs	Top	X		
		Sides			
BOX CULVERT	Wings	Top	X		
		Exp. Sides		X	
	Curbs	Top	X		
		Sides			
	Ends	Exp.		X	
	Median		X		
	Parapets & Fascia	Top	X		
Sides					X
CATCH BASINS **		Exp.			X
CURBING			X		
DROP INLETS **		Exp.			X
ENDWALLS		Top	X		
		Exp.		X	
GUTTERS		Exp.	X		
PRECAST PILES ***		Exp.			X
RETAINING WALLS		Top	X		
		Exp.		X	
SHOTCRETE		Exp.	X		
SLOPE PAVING		Exp.	X		
STEPS & COPING		Top	X		
		Exp. Sides			X

* See Subarticle 6.01.03-14 for finish following floating.

** Precast units excepted; See Subarticle M.08.02-4.

*** When required by special provisions.

Rubbed Finish: The entire surface shall be thoroughly wet with a brush and rubbed with a No. 16 carborundum stone or an abrasive of equal quality, bringing the surface to a paste. The rubbing shall be continued sufficiently to remove all form marks and projections, producing a smooth, dense surface without pits or irregularities. The paste formed by the rubbing as above described may be finished by carefully stripping with a clean brush, or it may be spread uniformly over the surface and allowed to reset. After the concrete has set for 7 days or such period as the Engineer may direct, the surface shall be rubbed again, with a carborundum stone, until a uniform even color is obtained. No mortar shall be used during this second rubbing. Curing, as specified elsewhere, shall be completed in all cases.

22--Testing Apparatus and Test Specimens: (a) The flexural strength of the concrete for structures shall be monitored by the evaluation of compressive strength cylinders. The compressive strength specimens shall be cast and cured in the field in accordance with AASHTO T 23. After proper curing, these cylinders shall be transported to the Division of Materials Testing for strength evaluation.

(b) Cylinders for 28-Day Compressive Strength: The concrete necessary to cast several cylinders for 28-day compressive-strength determinations shall be furnished by the Contractor from each day's pour. The necessary personnel and forms for casting these specimens will be furnished by the Department and the number of specimens required will be specified by the Engineer. These cylinders shall be cured in an approved concrete cylinder box, or boxes, as described in Section 6.12.

23--Opening to Traffic: Vehicular traffic shall be excluded from the structure until the concrete has developed a compressive strength of 28 MPa, or until the Engineer authorizes its opening to traffic. Use of equipment applying loads greater than the design capacity of the bridge or structure shall not be allowed.

24--Joint Seal: The Contractor shall seal joints where shown on the plans and elsewhere where directed by the Engineer.

Before placement of the sealing material, the joints shall be thoroughly cleaned of all scale, loose concrete, dirt, dust or other foreign matter. Projections of concrete into the joint space shall be removed. The joint shall be clean and dry before the sealing compound is applied.

The joint sealant shall be prepared and placed in accordance with the manufacturer's directions and with the equipment prescribed by the manufacturer. Any material improperly mixed or likely to set up before placement into the joints will be rejected and shall be replaced at the Contractor's expense.

The joints shall be sealed in a neat and workmanlike manner, free from all dust and foreign matter.

When the work is completed, the joints shall effectively seal against infiltration of moisture and water.

The sealing compound shall be flush with, or not more than 3 mm above the adjacent surface of concrete. Where directed by the Engineer, the joint shall be smoothed and leveled to the adjacent surface by cutting off all excess compound after the application. Any joint material which does not adhere or bond with the concrete surface of the joint shall be immediately removed and replaced at the Contractor's expense.

6.01.04--Method of Measurement: This work will be measured for payment as follows:

1--Concrete: The quantity of concrete shall be the actual volume in cubic meters of the several classes, with the exception of underwater concrete, completed and accepted within the neat lines as shown on the plans or as ordered by the Engineer.

When a concrete footing is to be constructed on bedrock, that quantity of concrete actually placed down to--but not exceeding 150 mm below the plan or revised plan footing grade--will be included for payment.

No deduction will be made for panels less than 38 mm in depth, nor for the volume of reinforcing bars or structural steel shapes when used as reinforcing, nor for pileheads. Also there will be no deduction made for the volume occupied by culvert and drainage pipes, scuppers, weep holes, public utility structures or any other opening, unless the surface area of any such single opening is 1 square meter or more.

Concrete for bridge decks, including curbs, sidewalks, railings, placed thereon or attached thereto, will be classified as Class "F" Concrete unless otherwise indicated on the plans.

In the case of culverts or drainage pipes, the computation of the surface area shall be based on the nominal diameter of the pipe, disregarding the thickness of the shell.

Underwater concrete when specified will be measured by the volume in cubic meters, completed and accepted within the horizontal limits of the cofferdam shown on the plans in which it is placed, and between the elevations established by the Engineer. When underwater concrete is not originally specified but is required, it will be measured by the volume in cubic meters, completed and accepted within the actual horizontal limits of the cofferdam in which it is placed and between the elevations established by the Engineer.

2--Joint Filler: This material will be measured by the area in square meters of the joint filler, of the type and thickness specified, actually installed and accepted.

3--Miscellaneous Material: Miscellaneous material such as metal flashing and metal used in expansion joints and bearings will be measured in accordance with the dimensions shown on the plans or as ordered by the Engineer.

6.01.05--Basis of Payment: Payment for this work will be made as follows:

1--Concrete: This material will be paid for at the contract unit price per cubic meter for "Class A," "Class C" and "Class F Concrete," respectively, complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto, including heating, all admixtures and joint sealer.

2--Underwater Concrete: When this class of concrete is constructed, it will be paid for at the contract unit price per cubic meter for "Underwater Concrete," complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

When no item for "Underwater Concrete" appears in the proposal, and is required, it will be paid for at 80 percent of the contract unit price for "Class A Concrete" which price shall include all materials, equipment, tools, labor, and work incidental thereto.

3--Ornament or Reverse Moulds: This material will be paid for at the contract lump sum price for "Ornament Moulds" complete in place, including furnishing, setting, removal and all incidental expense.

4--Joint Filler: Expansion joint filler will be paid for at the contract unit price per square meter for "Joint Filler for Bridges" of the type and thickness specified, complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

5--Miscellaneous Material: Metal flashing, metal in expansion joints and bearings, etc., will be paid for at the contract unit prices for the class of material in question.

No direct payment will be made for the work of testing the concrete in structures, any testing equipment, the instruction of its use, or for the concrete in or curing of the required test beams and cylinders as specified, or for completion dates set in the forms; but, the cost of this work shall be considered as included in the general cost of the work. The work of transporting and testing these beams and cylinders will be done by the Department without expense to the Contractor.

There shall be no direct payment for the cost of forming keys or construction joints, but the cost thereof shall be considered as included in the cost of the concrete items. Where steel dowels are used, this material will be paid for under the reinforcement item.

There shall be no direct payment for forming weep holes through the wall or for the pipe necessary for this purpose, but the cost thereof shall be considered as included in the general cost of the work.

There shall be no direct payment for the work of placing anchor bolts and similar material that is furnished to the Contractor at the site of the work.

Unless covered by specific contract items, any work performed by the Contractor in connection with utilities installations will be paid for as extra work.

The above provision shall not apply where the installation of equipment for the construction or support of utilities is included in the contract items.

Pay Item	Pay Unit
Concrete (Class A ,C,F)	m ³
Underwater Concrete	m ³
Ornament Moulds	L.S.
(Thickness and Type) Joint Filler for Bridges	m ²
Metal Flashing	kg